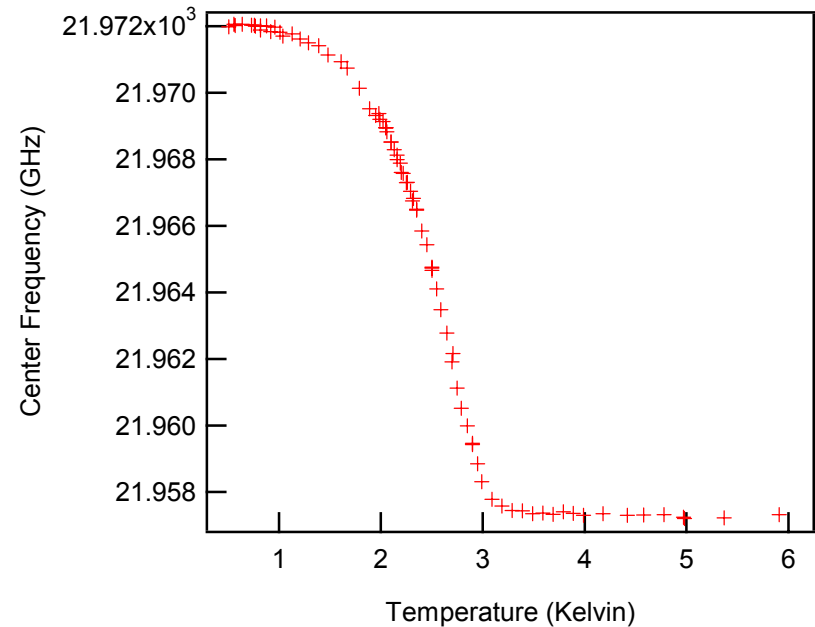
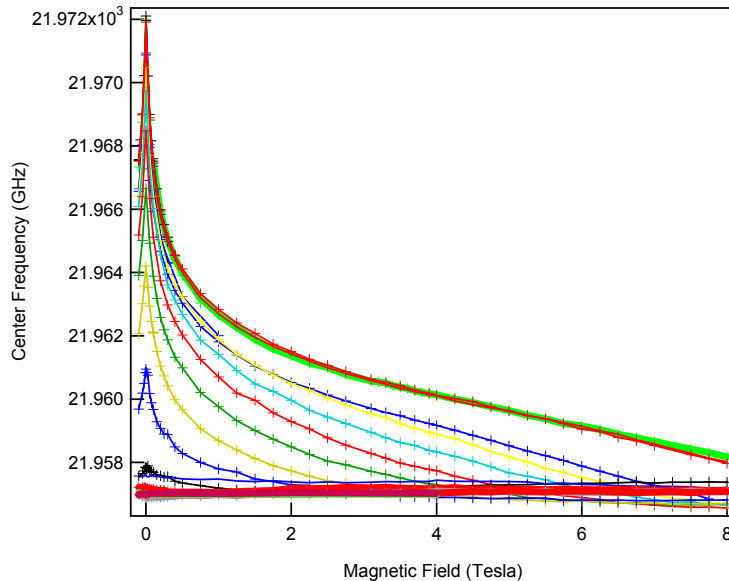


Commissioning of a low temperature high field microwave cavity facility

George Gruner, UCLA Physics, DMR-0102405

We have completed the commissioning of a continuous flow He₃ (base temperature 0.4 K) optical cryostat with a 9T magnet. Coupled with our group's capability to measure conductivity at low frequency ω , this system affords an *absolutely unique* ability to measure along three energy scale axes simultaneously (ω , T and B) in the so-called quantum limit $\hbar\omega \gg k_B T$ at low ω and T.



Using this system, we are working on measurements of thin film superconductors, which can be driven through a phase transition to an insulating state. Such a transition as a function of an external parameter like magnetic field is called a quantum phase transition and is an area of much current interest in condensed matter physics. On the left the resonant frequency of a microwave cavity with superconducting film inside is plotted as a function of magnetic field at various temperatures (0.5K at the top to 4.5K at the bottom). Because the frequency shift above the normal state is roughly proportional to the density of superconducting electrons, the finite shift (4 MHz) at large fields (7T) is indicative of significant superconducting fluctuations well into the insulating side of the transition. Even by itself, this is a significant finding. On the right is the zero field frequency as a function of temperature, which shows we can reach the effective zero temperature limit of the 22GHz conductivity. Research in this area is ongoing.

Integration of education and research

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•As the frequencies utilized in civilian and military communication move from the micro to the millimeter wave spectral range, the research equipment developed and used by the UCLA group is becoming increasingly important as characterization tools. In order to introduce some of these technologies into the undergraduate curriculum, the principle investigator (PI) has developed a laboratory course (displayed at right) where simplified versions of these techniques are used for educational purposes. Many of the experiments performed in this laboratory are based upon ones first developed in the course of the group's research in previous years. The laboratory is complemented by undergraduate and graduate classroom work based on the book "*Electrodynamics of Solids*" authored by the PI and published by Cambridge University Press.

•Evaluation of the optical properties of materials at micro and millimeter wave frequencies is essential for the development of novel communication devices. The group has performed materials characterization for companies including established organizations like Raytheon Inc. and for high technology startups such as Superconductor Technologies Inc. and Nanomix Inc. This shows the wide range of applicability that these techniques have, not only to fundamental solid state physics, but also as characterization tools in a wide range of industries.

